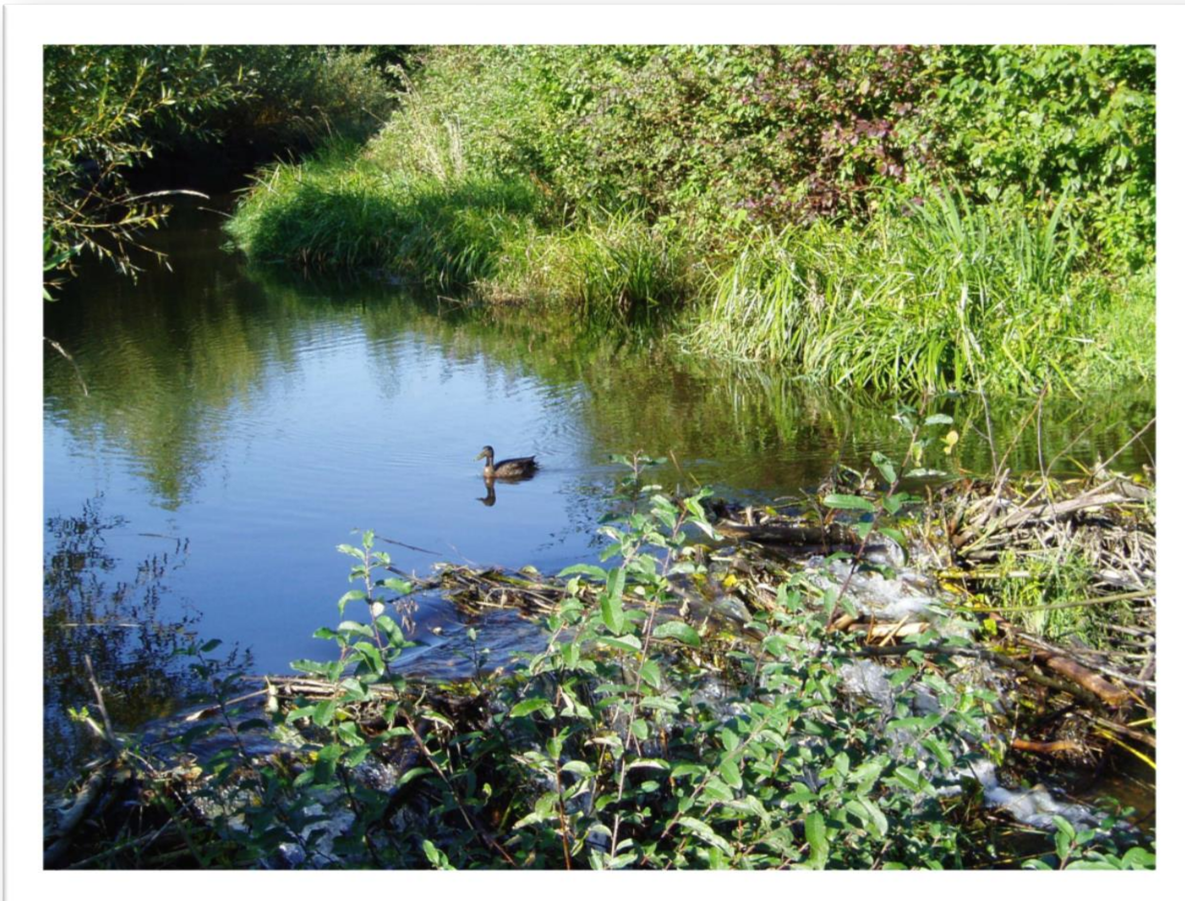
North Creek and Little Swamp Creek Sample Results 2014

Fecal Coliform Bacteria Total Maximum Daily Loads



Water Quality Monitoring

Annual Summary Report

February 2015

City of Bothell™

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City of Bothell™

Table of Contents

List of Figures and Tables

Figures

Tables

Introduction

In 1996, the Washington State Department of Ecology (WDOE) listed North Creek and Swamp Creek on the 303 (d) list of impaired water bodies for fecal coliform bacteria (FCB) and dissolved oxygen Total Maximum Daily Loads (TMDLs). (http://www.ecy.wa.gov/programs/wq/303d/1996/index-1996.html).

North and Swamp Creek are contaminated by excessive levels of bacterial pollution. As a result of the bacterial pollution problem, WDOE worked with local municipalities to develop the **North Creek Fecal Coliform Total Maximum Daily Load Detailed Implementation Plan** (Svrjcek, 2003) and **Swamp Creek Fecal Coliform Bacteria Total Maximum Daily Load, Water Quality Improvement Report and Implementation Plan** (Svrjcek, 2006). In the plans, WDOE established water quality monitoring requirements for local municipalities that collect, treat, and/or convey stormwater.

In 2007 and renewed in 2013, WDOE issued a National Pollution Discharge Elimination System (NPDES) stormwater permit to all small municipalities. The NPDES permit conditioned TMDL(s) among other things to identify long-term monitoring sites. Collection of data and site selection was detailed in Quality Assurance Project Plan (QAPP) (Kalenius, 2007). The City of Bothell's goal is to improve water quality to meet state standards for FCB levels.

Specific source contributors in North Creek have been identified through the use of DNA testing (Kalenius, 2008). Pet waste, failing septic tanks, sewage, wildlife, and illegal discharges were all identified as sources. It is assumed that Swamp Creek has a similar bacteria source profile.

This report provides an annual update on monitoring as described in the 2007 QAPP (Kalenius, 2007). The City of Bothell understands the need to work together with others to understand the bacterial pollution problem in North and Swamp Creeks and find solutions. The water quality monitoring activities reported here support those efforts. Still, more can be done and in 2014 the City initiated bi-watershed quarterly meetings of all interested parties to discuss potential collaborations of sharing data and watershed management actions. Initial response has been positive.

Applicable Water Quality Standards

Allowable bacteria concentrations in North Creek are designed to protect Lake Washington, one of the most important recreational waterbodies in Washington State. State Water Quality Standards (Washington Administrative Code 173-201A) establish the use of extraordinary primary recreational contact for both waterbodies. The Standards requires that water quality in these streams meet a geometric mean of 50 cfu/100 mL, and an upper tenth percentile value not to exceed 100 cfu/100 mL.

Basin and Sampling Site Descriptions

North Creek

The North Creek basin drains approximately 30 square miles and discharges to the Sammamish River, which is a tributary to Lake Washington. The watershed is comprised of the main stem of North Creek and all the tributaries that contribute to it. Land use within the basin is primarily urban or suburban with some pockets of rural and forested land. The basin is being rapidly developed for residential and commercial use. Urbanization and land development activities greatly affect water quality in the basin through riparian corridor alteration, conversion of forests, inadequate retention/detention of stormwater from new and existing impervious surfaces, and poorly treated stormwater run-off.

North Creek is located predominantly in south Snohomish County (Figure 1). The headwaters originate in the Everett Mall Way area of south Everett and flow southerly for 12.6 miles before discharging to the Sammamish River, within the City of Bothell. The Sammamish River drains into Lake Washington and ultimately through the Ballard Locks to Puget Sound. The last 1.5 miles of North Creek is located in King County (Bothell). The stream gradient is flat, decreasing from about 50 feet per mile in the upper basin to less than 20 feet per mile near the mouth. The seven major sub-basins within the watershed are main stem North Creek, Penny Creek, Silver Lake Creek, Nickel Creek, Silver Creek, Tambark Creek, and Sulphur Springs Creek (Figure 1). The major lakes are Silver Lake, Ruggs Lake, and Thomas Lake.

The watershed is nearly 10 miles long and 3 miles wide, and encompasses an area of about 19,000 acres. Approximately 10 percent of the watershed lies within the city of Everett; 23 percent lies within the city of Bothell; 12 percent lies within the city of Mill Creek; and the remaining 55 percent lies within unincorporated Snohomish County. Five percent of the total area lies within King County, and this area is within Bothell’s city limits.

North Creek watershed in Bothell is comprised of multi-land uses: residential, retail, and business parks containing business and light industry, with residual open space. The residential development is mixed sewer and septic averaging 4-6 dwellings per acre. Three sample locations were selected to best represent the various land uses (Figure 2).

In 2011 the sample site NCLD was moved upstream to just north of 228th St SE. This was due to sample location at 240th St SE undergoing bridge replacement and ongoing issues with accurate flow gage information.

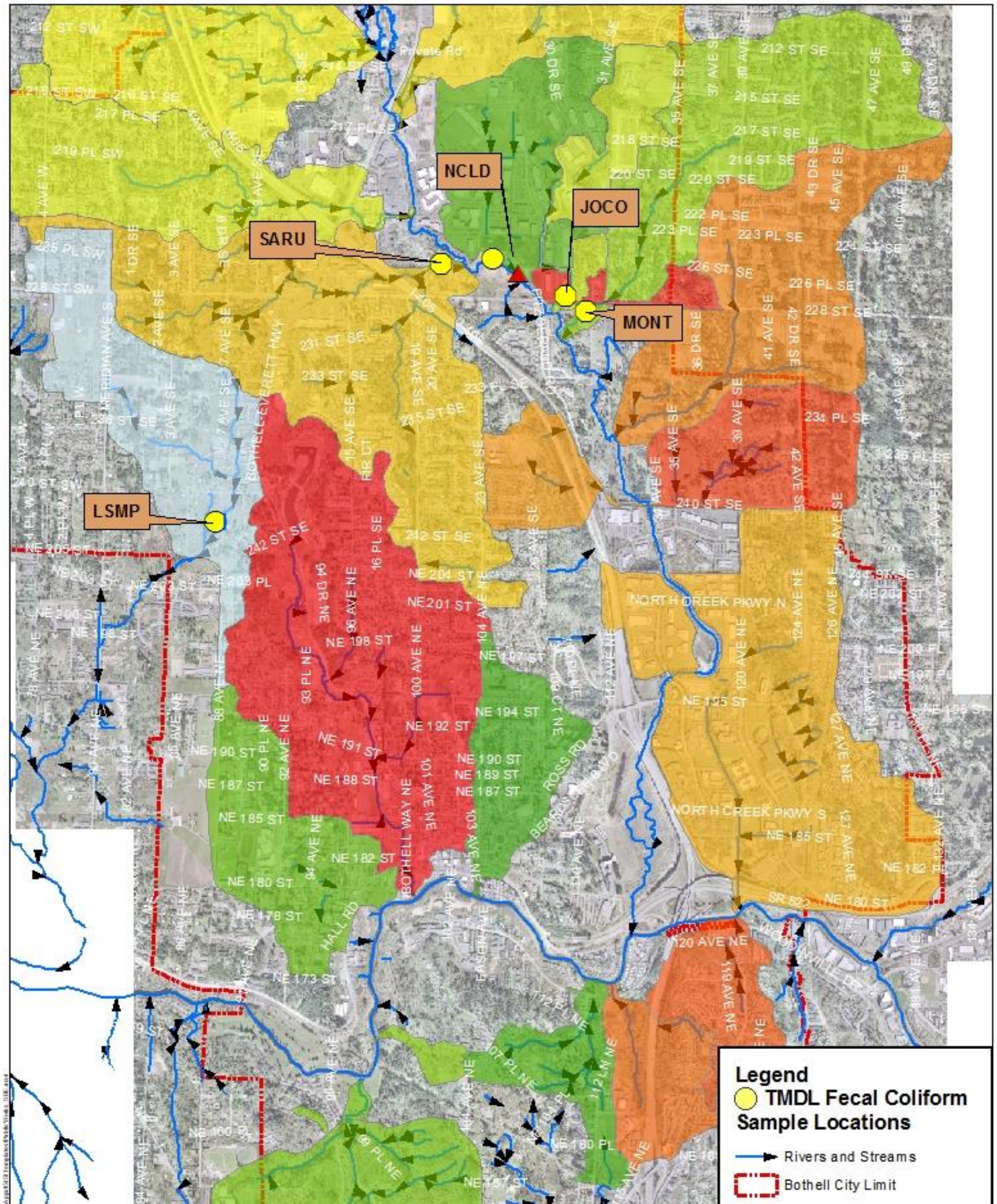

Figure 1. TMDL fecal coliform bacteria sample locations in North and Swamp Creek..

Swamp Creek

The Swamp Creek watershed spans about 12 miles in length from top to bottom. Starting just below State Route 526 in Everett, the main stem of the creek winds 14 miles through the watershed before it flows into the Sammamish River at Kenmore. Swamp Creek contributes to the quality of water in the Sammamish River, which empties to upper Lake Washington 0.7 miles below the Swamp Creek confluence.

Swamp Creek is typical of Puget Sound lowland watersheds. In the gently sloping upper basin, Swamp Creek flows through a narrow valley which gradually broadens to a floodplain almost .75 miles wide in the lower basin. The middle basin also contains a narrow valley with steep slopes in excess of 15 percent just south of the I-405 and I-5 crossing. Elevation in the headwaters is approximately 520 feet, while the elevation at the mouth is about 20 feet above sea level. The stream gradient is flat, decreasing from about 50 feet per mile in the upper basin to less than 20 feet per mile near the mouth. Scriber Creek, Little Swamp Creek, and Martha Creek are the largest of the 19 tributaries to Swamp Creek. Major lakes in the Swamp Creek watershed are Scriber Lake, Martha Lake, and Stickney Lake (SWM 1994 & 2000).

The watershed is nearly 12 miles long and encompasses an area of about 7,500 acres. Approximately 20 percent of the watershed lies within the city of Lynnwood; 8 percent lies within the city of Kenmore, 5 percent lies within the city of Bothell, 5 percent lies within the city of Brier, 5 percent lies within the city of Everett, and the remaining 57 percent lies within unincorporated Snohomish County.

Most of Swamp Creek and its tributaries are shallow and unsuitable for full-immersion swimming activities. However, several noteworthy exceptions are Wallace Park in Kenmore, Lake Martha, and Lake Stickney. Lake Scriber in Lynnwood is large and deep enough for swimming, but this activity is not encouraged by the City. Although public access to the creek is largely limited to road crossings and a few parks, Swamp Creek is fully accessible to adjacent land owners, their children, and in some cases, their neighbors. Limited boating opportunities exist where Swamp Creek meets the Sammamish River.

In the late 1990's, Swamp Creek watershed was highly urbanized with about 50 percent of the land in residential or commercial use, 30 percent with forest cover, 10 percent in commercial use, and less than 10 percent rural property (MRLC, 1999 & SWM, 2002). Commercial and light industrial uses are primarily located within Lynnwood and Everett. Small farms and pastures are most common in the middle of the watershed, especially in Brier and unincorporated Snohomish County. The watershed is located within the US Census Defined Urbanized Area; therefore, it is expected that population growth and urban development will be concentrated in this area.

An examination of orthophotos taken in 1995 was performed as part of the Habitat Inventory and Assessment of North, Swamp, and Little Bear Creeks (KCWLR, 2001). This land use analysis method is different than the one used for Swamp Creek's Water Quality Improvement Plan and suggested that forested cover is only 20 percent, mostly composed of deciduous trees. Road density was highest in the Scriber Creek sub-basin.

City of Bothell Sampling Sites Descriptions

North Creek

Perry Creek sample site (SARU) is located directly behind Salmon Run Apartments. This stream has two branches. One drains from 9th Avenue SE wetland through I-405 and a commercial area. The second drains from ponds in the Green Acres Mobile Home Park northward through a steep, eroded gully. Both of these drainages pass through a wetland behind the Village Square neighborhood, where local flooding occurs during heavy rains before entering North Creek.

Figure 2. Perry Creek after a heavy rain event.

JOCO site is an unnamed creek running south out of the Highlands Campus Business Park property north of 228th Street SE and east of 29th Drive SE. A headwater wetland feeds the channeled and piped stream corridor. The site location is on the north side of 228th Street SE.

Figure 3. JOCO monitoring site, an unnamed tributary that flows through a business park.

The Palm Creek sampling site, MONT, is located at Whole Earth Montessori. Palm Creek's water source is a large wetland in a ravine below the area of R-1 zoning. The stream enters a pipe in a trailer park, returning to an open channel in a defunct trout farm that channels the stream through cement weirs. Sediment fills the channel and the surrounding knotweed does not provide adequate shading. The stream reenters a pipe to cross under 228th Street SE, daylighting again on the south side just above the sample site.

Figure 4. Palm Creek, upstream view of sample station site MONT.

Swamp Creek

Little Swamp Creek (LSWP) was added as a new sample location beginning in 2010. In 2009, sampling by others found elevated levels of fecal coliform in the stream along 7th Avenue SE. The site follows all the same protocol for North Creek's QAQC plan. The site was moved in 2011 to just downstream of the 7th Avenue SE stream crossing.

Figure 5. Little Swamp Creek, view across 7th Avenue SE and upstream of Little Swamp Creek sample station site LSMP-II.

Pollution Sources – North and Swamp Creek

Pollution in the basin(s) comes from both point and nonpoint sources. The point source contributions come from stormwater and include those discharges currently covered by National Pollutant Discharge Elimination System (NPDES) stormwater permits[1], as well as those from municipal separate storm sewer systems (MS4s) that are currently covered by NPDES stormwater permits that meet the definition of a points source in 40 CFR 122.2. Nonpoint water pollution most commonly results from poor land use management, such as inadequate agricultural practices, failing on-site septic systems, and untreated stormwater runoff.

Stormwater from urban areas is likely to carry pet wastes to nearby streams. Urban stormwater can carry bacteria from pet wastes on the ground, surfacing wastewater from failing septic tanks, excess nutrients from lawns and gardens, and pollutants associated

[1] More information available at http://www.epa.gov/ow/regs/permit.html.

with activities such as car washing and sidewalk cleaning. Urban and suburban development is continuing in the North and Swamp Creek watersheds; thus, water quality impacts from stormwater runoff are increasing as well.

Many areas of the watersheds have poor soils for locating on-site septic systems, that may be resulting in failing or inadequate septic systems, which can contribute bacterial and nutrient pollutants.

Some areas are still rich in wildlife, such as water fowl, deer, and beaver. Fecal coliform bacteria originating from these sources are considered part of the natural background and are generally not considered a source of pollution.

Impaired Areas

North Creek

North Creek was included on Washington's 1996 303(d) list because of numerous exceedances of fecal coliform bacteria standards; 29% to 45% of samples collected at several locations in North Creek, by Snohomish and King Counties between 1992 and 1997, exceeded the upper fecal coliform criterion. Based on monitoring conducted by the various municipalities in the watershed, we now know that the extent of the bacteria pollution problem stretches throughout the basin.

Swamp Creek

Since the year 2000, a consistent pattern of bacterial pollution has been observed in Swamp Creek. It was placed on Washington's 1996 303(d) list for fecal coliform exceedance and low dissolved oxygen. All areas previously sampled in the basin exceed state criteria for bacteria at all times of the year (Svrjcek, 2006). During the dry summer months when stream flows are low, bacteria levels rise far beyond both the geometric mean criterion of 50 cfu/100 mL and the 90th percentile criterion of 100 cfu/100 mL. During the wetter months of the year, bacteria concentrations improve at each site, but not enough to meet state standards.

Since 2010, the City has been monitoring Little Swamp Creek, a tributary to Swamp Creek (Figure 1). Sampling has shown periods of high bacteria levels during the dry season and lower concentrations during the wet season. Source tracking investigations found potentially contributing sources from a failed septic system and a duck feeding pond. The septic system was repaired in 2010 and efforts are ongoing at the duck pond to discourage people from feeding the ducks. Recent surveys in 2014 have found no evidence of people feeding ducks, yet the ducks remain at the pond.

Although it is not reflected in Ecology's current Water Quality Assessment, North and Swamp Creek do not consistently meet state standards for temperature or dissolved oxygen, and benthic invertebrate surveys indicate that overall aquatic habitat quality ranges from fair to poor (SWM, 2000 & 2002).

Project Description

The goal of monitoring at established long-term monitoring stations is to develop trend analysis to determine direction of bacteria concentrations (i.e. whether it is falling or rising). The City has established four long-term stations in North Creek and one in Swamp Creek. The North Creek stations are mainstem North Creek (NCLD) and three tributaries – Perry Creek (SARU), Junco Creek (JOCO), and Palm Creek (MONT). Swamp Creek's station is located on Little Swamp Creek (LSMP-II). Currently, the City has about seven years of data for North Creek with a total of 84 data points for each site. Swamp Creek has four years of data and 48 data points. General findings are limited in scope. Decreases in fecal bacteria have been noted at most sites, yet there is no causal mechanism to account for the decrease.

This report provides monitoring procedures and results. The basic procedures for sample collection and processing of samples at the long-term sites are sufficient for simple trend comparison among and between sites.

Relationship of this Monitoring with Existing Programs

Long-term monitoring currently performed by King and Snohomish counties will be important to this monitoring program. Flow gauging stations operated by these entities are critical for establishing when stream flow is dominated by stormwater runoff. Additional water quality stations added by City of Bothell and other local cities will round out the long-term monitoring needs. At this time, the City has established five monthly monitoring stations.

Source Tracking

Beginning in 2010, City of Bothell and Snohomish County entered into an interlocal agreement to improve monitoring within North Creek. In 2010, the City contracted with Snohomish County to conduct bacteria microbial source tracking efforts (Britsch, 2009). The microbial source tracking was determined by monitoring results indicating prolonged elevated levels of fecal bacteria exceeding 200 colonies per 100 mL.

In late 2009 and throughout 2010, WDOE lead a collaborative effort with the City to identify sources of high fecal coliform bacteria in Little Swamp Creek. Results from the intensive sampling regime allowed for source tracking of potentially active sources of bacteria discharges to Little Swamp Creek. In 2010, the City added a long-term monitoring station for fecal coliform bacteria in Little Swamp Creek.

In 2010, Snohomish County Surface Water Management Program staff carried out contaminant source survey in Perry Creek. A similar survey was conducted in 2012 on

Queensborough Creek. Each survey provided its findings and recommended actions. Perry Creek had no identified point source illicit discharges linked to fecal bacteria, and likely sources of non-point were from wildlife in wetland ponds, pet waste, and potential nutrient loading from residential lawns and parks. Similar non-point sources were found in Queensborough Creek, except no wildlife concerns were noted. Point sources were identified but could not be verified. Potential discharges of human waste from spalling sewer standpipes and human use was observed. The latter is part of ongoing source tracking efforts initiated in August 2014. The results are not yet available.

Little Swamp Creek is receiving targeted source identification and elimination efforts (Loch, 2014). The ongoing effort began in August 2014. The goal is to determine the effectiveness of eliminating duck feeding activities at a small duck pond located in the business site of Country Village. Early indications are that duck feeding is no longer occurring, but a significant number of ducks remain at the pond, possibly feeding on aquatic algae, plankton, and zooplankton.

The results of the two targeted source identification and elimination efforts will be forthcoming in a separate report.

Data Quality Objectives

Data quality objectives are qualitative and quantitative statements of the precision, bias, representativeness, completeness, and comparability necessary for the data to address project objectives. The primary indicators of data quality are precision and bias, which together, express the data's accuracy.

Precision, expressed as the standard deviation of replicate sample analyses, is a measure of data scatter due to random error. Bias is a measure of the difference between the result for a parameter and the true value due to systematic errors. Potential sources of errors include sample collection, physical and chemical instability of samples, interference effects, instrument calibration, and contamination. Random error affects the determination of bias; thus, bias estimation may be problematic. Consequently, dedication to established protocols is one method used to reduce concern over sources of bias (Lombard & Kirchmer, 2004).

Fecal coliform bacteria levels are highly influenced by the biological component in the aquatic environment and can be subject to sample contamination problems. Table 1 summarizes the laboratory accuracy and analytical reporting limits for parameters that can reliably be used for decision-making. Seasonal sampling and other sampling design features will be used to better evaluate critical conditions to determine water quality compliance with state bacteria standards.

Our goals for evaluating impacts to water quality require the ability to detect "differences." These differences can be based on: 1) a simple comparison of upstream and downstream locations (e.g., "bracketing", BMP effectiveness evaluations), or 2) determining a trend over time at points on a stream in the absence of changes to upstream land use activities.

Table 1. Quantitative Data Quality Objectives

Analysis	**Accuracy** % deviation from true value	**Precision** relative standard deviation	**Bias** % deviation from true value	**Required Reporting Limits** (concentration)
LABORATORY ANALYSIS				
Fecal Coliform (MF)[1]	N/A	RSD ± 30%	N/A	1 colony forming unit per 100 mL

[1] *Using Standard Method 9222D*

Upstream/Downstream Differences

Sources of very high fecal coliform concentrations, such as failing septic systems or leaking sewer lines, can have severe effects on overall stream concentrations even when the volume discharged is low. However, when the concentration upstream of a source is high, the change due to the source can be undetectable.

Trends Over Time

The ability to detect changes in water quality (trends) is the cornerstone of a long-term sampling design. A historical perspective, which only long-term records can provide, is necessary in order to make informed decisions about water quality assessments. Data quality objectives were developed to support statistical requirements for trend analysis.

Sampling Process Design

The project objectives of detecting trends and comparing results to the state water quality standards require collecting samples regularly at the same stations over a long time span. This approach will provide randomly collected data for unbiased analysis in the future. No attempt will be made to avoid sampling due to weather or other environmental conditions unless staff's safety is compromised.

Sampling related to the TMDL is limited to bacterial pollution measured using fecal coliform testing. High quality flow monitoring (daily flows) is also required at selected representative stations throughout the basin. Although WDOE encourages monitoring of temperature and dissolved oxygen levels as well, these additional parameters are not required.

The frequency for monitoring at the long-term sites is monthly. City of Bothell will attempt to sample the first Monday/Tuesday of the month. Small deviations for holidays, illness, and other business reasons are anticipated. This sampling regime will occur throughout the NPDES Phase II Permit life.

Figure 1 shows water quality stations for the long-term monitoring component of this project. North Creek's long-term flow monitoring is conducted by Snohomish County Surface Water Management at 240th Street SE, site NCLD (Figure 1). Swamp Creek's long-term flow monitoring is conducted by Snohomish County Surface Water Management at two locations; one near State Route 524, and the other at Locust Way just north of 228th Street SE (Figure 2). King County conducts long-term flow monitoring at one location in the lower basin (Figure 2).

Sampling Procedures

Overview

Fecal coliform bacteria is the preferred indicator of disease-causing microorganisms in Washington State. There are two standard methods for the detection of coliform bacteria – the Membrane Filter (MF) technique and the Most Probable Number (MPN) index. The MF and MPN methods are frequently not comparable. The United States Environmental Protection Agency (USEPA) currently recommends the MF procedure because it is faster and more precise than the MPN technique (EPA, 2001). However, MPN is better for use in chlorinated effluents, highly turbid waters, and salt or brackish waters. Ecology requires all partners in this program to have samples analyzed by state-accredited laboratories using the MF technique SM9222D. City of Bothell used TestAmerica Analytical for this purpose until June 2008, and then switched to AmTest, Inc.

Planning

Bacteria samples will be collected in sterilized bottles obtained from AmTest, Inc.

Downstream samples are collected first. Samples will be taken downstream working upstream to minimize the possibility of collecting fecal coliform from sediments that may have been disturbed during the current sampling activities.

In late 2008, the City elected to add analysis for E. Coli and Total Coliform in addition to Fecal Coliform Bacteria count. All QA/QC is consistent with that stipulated for FC when testing for E. Coli and Total Coliform.

Field Procedures

Ambient water quality samples collected as part of this QAPP will generally use the "dipping method." The dipping method is intended to collect the most representative sample taken at a single point in time (also called a grab sample). Staff will avoid collecting water from near the surface and collect samples from the center of flow (thalweg) when possible. A notation will be made in the field notebook if surface samples are taken.

Field measurements and comments are recorded on either a form prepared prior to sampling, ideally in a notebook of water resistant paper, or loose-leaf water resistant paper. All notes should be stored in a safe location after a sampling run. At a minimum, staff should record project name, station location, date and time of sample collection, and sample number. Other useful information may include staff gauge or tape down measurements, estimates of discharge, field quality control information, field meter measurements (if applicable), weather conditions, and comments about turbidity, color, and odor.

A word about safety: Safety is a primary concern whenever working in or near waterbodies. Many times, sampling locations are established close to roadway crossings to facilitate access in right-of-ways and to reduce travel times to the actual sample site. In these cases, the need for life vests, reflective clothing, orange marking cones, and flashing lights will be considered to protect staff from injury and to alert passing drivers to their presence on the roadside.

Here are the general procedures for taking a proper fecal coliform sample.

Sampling Procedure

1. A sterilized polypropylene sample container provided by the accredited laboratory is used. The minimum sample size is 250 mL.
2. For sites that require entering the stream, care is taken to not stir up sediment. Sites are approached from a downstream to upstream direction.
3. The sample bottle is uncapped. Care is taken not to contaminate the inside of the bottle or the cap.
4. The bottle is inverted and plunged, mouth down, through the surface to a depth of 15 to 30 cm (6 to 12 inches, mid-depth of stream where feasible). While under water, the mouth of the bottle is rotated into the current. The sample bottle is brought back to the surface in an upright position. Water is poured off enough until the water level is at the shoulder of the bottle. This allows room for mixing the sample before analysis at the lab.
5. After recapping the bottle, the bottle is placed on ice upon reaching the vehicle.
6. Other notes:
   - **Do not rinse the bottle.**
   - **Do not pour water into the fecal bottle from another container.**

Field Quality Control

Field Replicates

Total variability (precision) for field sampling and laboratory analysis will be assessed by collecting field replicates. In some cases field duplicates, field blanks, and field splits may also be appropriate.

Field replicates are two samples collected from the same location at the same time. A second bottle is plunged side-by-side with the regular sample. Field replicates will be collected at the rate of 10%, with a minimum of one field replicate per sampling run. If using a pole to collect samples, it may not be possible to collect the samples side-by-side. In this case, the field replicate is collected at the same time of the regular sample. Staff is directed to make comments in the field notes if the samples were not collected side-by-side.

Replicate results that are "non-detects" cannot be used to estimate precision. Similarly, the variability found at low concentrations cannot be used to estimate the variability at higher concentrations, and vice versa. Variability, or precision, is estimated as the standard deviation of a number of results. The standard deviation varies with the magnitude of the results. Separate estimates of standard deviation will be determined for each range of concentration. By collecting field replicates often over a long time period, we should be able to calculate standard deviations for a wide range of concentrations.

Field replicates are labeled in such a way as to give the impression that they are completely separate samples as such before they are sent to the laboratory. The laboratory analysts are not made aware of the fact that they are handling field replicates.

Sample Container

A sterile glass or polypropylene bottle will be used for all samples collected. (When working with laboratories associated with wastewater treatment plants, it should be specified that the bottle must be empty, with no sodium thiosulfate or other dechlorinating agents.) Although the type and size of bottle will likely be determined by the laboratory's preferences, WDOE routinely uses polypropylene 250 and 500 mL bottles without preservative for stream samples. Sample bottles should be autoclaved with caps covered in aluminum foil or otherwise sterilized and supplied by an accredited laboratory.

Select a bottle according to the following criteria:

- Use the 500 mL bottle if sampling for enterococci in addition to fecal coliform.
- Use bottles with EDTA added if high metal concentrations are suspected.

At WDOE, empty bottles have a holding time; three months for bottles without thiosulfate or EDTA, and one month for bottles with thiosulfate or EDTA. Individual laboratories may have different recommendations.

Field Processing

No field processing is required.

Sample Storage

All samples are placed in an ice chest with ice packs immediately upon return to the vehicle. The samples are stored in the dark. For chain-of-custody procedures, the vehicle is locked whenever it is not in view of sampling personnel.

Source Tracking Surveys

North Creek

Snohomish County Surface Water Management has developed source tracking methodology for fecal coliform bacteria (Britsch, 2009). Perry Creek was subject to a Phase II contaminant source survey (CSS). Field surveys included a windshield survey (driving the roads) and stream walk, where and when feasible, to identify presence of specific sources of bacteria. Types of activities included identifying illicit connections, evidence of failing septic systems, catch basins with accumulated sediment greater than 40%, presence of dog parks, and presence and numbers of birds and dogs. For a complete description of methods, refer to Perry Creek Contaminant Source Survey, 2010 Summary Report (SWM, 2010). The results were then translated into a set of recommendations. A similar effort occurred in 2012 on Crystal Creek. Those results and recommendations are included in SWM 2012.

Swamp Creek

The source tracking effort conducted followed a simple pattern of collecting multiple upstream and downstream samples. The sampling was conducted on multiple occurrences and modified based on the previous sample results. The selection of sampling sites was based on narrowing down to a finite world of possible contributing sources. In this manner, sampling typically progressed upstream until no other possible sources of bacteria could be identified.

Measurement Procedures

Field

Station Information

City of Bothell has already determined the coordinate information for its proposed long-term sites and entered this information into Ecology's EIM database. Ecology has indicated that it is not necessary to determine coordinate information for short-term monitoring locations associated with source tracking activities.

Office

Stream Discharge Data

Currently, stream gauging networks are provided by Snohomish County and King County. At present, three stream gauges are functioning on Swamp Creek and North Creek. Snohomish County monitors at site NCLD, which is located in lower North Creek just upstream of 228th Street SE in Bothell. In 2011, the NCLU site was at 240th Street SE but was abandoned due to a bridge replacement project. It was relocated upstream to 228th Street SE in late 2011. Mill Creek and Snohomish County jointly maintain and operate a flow-monitoring station on Penny Creek near its confluence with North Creek.

Lab

Fecal Coliform – Membrane Filtration Method

Laboratory analyses for fecal coliform bacteria were performed by two separate laboratories accredited by Ecology. The analytical method used is described by Standard Methods for the Examination of Water and Wastewater, No: 9222 D, 24-hour Membrane Filter (MF) procedure. The detection limit and the precision for this method are both 1 colony per 100 mL. Densities were reported as fecal coliform bacteria per 100 mL.

Quality Control

Quality control procedures used during field sampling and laboratory analysis provided estimates of the accuracy of the monitoring data. Field replicates were used to determine compliance with measurement quality objectives. Total variation for field sampling and analytical variation were assessed by collecting replicate samples and performing lab replicates as discussed below.

Table 2. Summary of Field and Laboratory Quality Control Procedures

Analysis	Field Blanks	Field Replicates	Lab Check Standard	Lab Method Blank	Lab Replicates	Matrix Spikes
Fecal Coliform (MF)	N/A	1/10 samples	N/A	1/run	1/10 samples	N/A

Field

Field Notes

The notes from each field run were tabulated and compared to chain-of-custody forms and laboratory results for completeness and accuracy. Any problems and associated corrective actions were recorded. Any unresolved problems were flagged and discussed in the data report.

Fecal Coliform and E. Coli Bacteria

Total variability for field sampling and laboratory analysis were assessed by collecting replicate samples at the rate of 10% of regular samples collected, and a minimum of one replicate per sampling run.

Laboratory

Fecal Coliform and E. Coli.

Routine laboratory quality control procedures will be followed. Laboratories should perform at least one analytical duplicate per sampling run. Duplicate laboratory analysis refers to analyzing duplicate aliquots from a single sample container. Each sample is carried through all steps of sample preparation and analysis. The results for laboratory duplicates provide an estimate of analytical precision, including the homogeneity of the sample matrix.

Field personnel may want to request that the analytical duplicate be performed on the same sample that accompanies the field replicate, as this allows staff to estimate total and analytical variability from results for the same sample. There is no advantage to randomly selecting samples for duplicate analysis.

If the samples selected for duplicate analyses do not contain measurable amounts of fecal coliform, the results provide no information on precision. Similarly, if the laboratory selects samples from another study with significantly different levels of fecal coliform or different matrices, the estimate of precision may not be applicable to the samples.

The laboratory must report the results of their analytical duplicates.

Data Qualifiers

Each laboratory had its own list of data qualifiers. Test America Analytical and AMTest, Inc. supplied City of Bothell their list of relevant data qualifiers and supporting documentation so that a cross-reference list could be developed. The laboratories were instructed to contact the City immediately if values over 1000 cfu/100 mL were observed.

Data Management Procedures

Recording field measurements

Time, location, weather conditions, and other observations and environmental factors were recorded at the time of sampling and maintained for public record purposes. Laboratory reports, worksheets, and chain-of-custody records were filed together and stored in a binder and other organized forms.

Data qualifiers were explained in all reports as needed. Tables were used to track seasonal compliance with water quality standards using a dry season period of June through September.

Data Verification and Validation

Verification

Data was verified by examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Once measurement results were recorded, they were verified to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions.
- Results for QC samples accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers were properly assigned where necessary.
- Data specified in Sampling Process Design were obtained.
- Methods and protocols specified in the QAPP were followed.

Qualified and experienced laboratory staff examined lab results for errors, omissions, and compliance with QC acceptance criteria. Findings were documented in each case narrative if and when they occurred.

Validation

Data validation followed verification. It involved a detailed examination of the data package, using professional judgment to determine whether the method quality objectives (MQOs) were met (Table 3). Validation involved evaluation of relative percent differences between field duplicates and lab splits. Acceptable precision is outlined in Table 5.

Data Results 2014

Verification

Verification of data found it to be consistent, correct, and complete, with no errors or omissions. Results of QC were calculated and found to be within acceptable tolerance. Hence, established criteria for QC results were met. Data qualifiers were properly assigned by laboratory and by field personnel as needed. Data specified in Sampling Process Design were obtained. Methods and protocols specified in the QA Project Plan were followed.

Validation

Data validation found no anomalies. Method quality objectives were met with a Relative Standard Difference (RSD) of replicates to within the ± 30% tolerance range (Table 3). Duplicate analysis of percent relative difference was within RSD of ± 30%.

Table 3. Field Replicate and Lab Duplicate Analysis for 2014

Field Replicate Analysis, 2014 FC Bacteria				Lab Duplicate Analysis, 2014 FC Bacteria			
Field	FC cfus/100ml			Lab	FC cfus/100ml		
Date	Site	Replicate	%RPD	Date	Sample	Duplicate	%RPD
1/13/2014	1	**2**	-66.6667	1/13/2014	2	1	-66.6667
3/3/2014	68	**62**	9.2	3/3/2014	620	640	-3.2
3/24/2014	64	**120**	-60.9	3/24/2014	120	100	-18.2
4/14/2014	74	**64**	-14.4928	4/14/2014	98	100	2.0
5/12/2014	72	**38**	-61.8	5/12/2014	10	6	-50.0
6/23/2013	25	**25**	0.0	6/23/2013	85	80	-6.1
7/14/2014	220	**200**	9.5	7/14/2014	780	900	-14.3
8/4/2014	70	**100**	-35.3	8/4/2014	100	85	-16.2
9/17/2014	14	**15**	-6.9	9/17/2014	660	700	5.9
10/15/2014	86	**72**	-17.7	10/15/2014	430	470	8.9
11/19/2014	24	**42**	54.5	11/19/2014	18	10	-57.1
12/17/2014	2	**4**	66.66667	12/17/2014	4	4	0.0
Avg	**60**	**62**	-3.3	Avg	**244**	**258**	5.6
Std	**58.98998**	**56.78828**	3.803	Std	**292.486**	**325.508**	16.827
RSD=	**98.31664**	**91.594**			**119.9123**	**126.1659**	

# of Samples Collected = 48
# of Field Replicates Collected = 12
Field Replicates = 25% for Sampling Period.
RSD= 98.31664 @ + or - 30% = +/ - 29.5

Field Replicate results fall within the 30% RSD.

Lab duplicates were typically within a 10% tolerance range. Annual 12-month average was 5.6%.

Field Sampling

Field sampling began in October 2007 and will continue until further noted. One station was added for Little Swamp Creek in 2010. No unusual observations were detected. Staff typically sampled on the first Monday or Tuesday of each month. This shifted to later in the month at times, due to staff availability. In 2014, sampling shifted to the third Wednesday of the month. The change was a watershed wide agreement with all other jurisdictions. It was chosen to see if relationships exist between sampling stations throughout the watershed of North and Swamp Creeks. For example, if readings were high in lower North Creek Tributaries, were they on the same day high elsewhere in the watershed?

Results

Results of sampling are tabulated in Table 4. In 2008, E. Coli was added to the sample matrix for trend analysis. It was dropped in August 2014. E. Coli levels are well-correlated to fecal bacteria levels; hence, they did not provide additional diagnostic capabilities. Highlighted in red font are geometric means that exceed state water quality standards of less than 50 Fecal Coliform colonies per 100 mL or having a geometric mean of 90th percentile, greater than 100 Fecal Coliform colonies per 100 mL.

The trend observed during wet season (November through May) and dry season (June through October) since 2006 to 2013 is variable between streams (Table 4, Figure 6, & Figure 7). The trend has been one of decreasing or unchanged since 2010 during dry weather sampling, and a consistent increase since 2010 during wet season.

The water year period is from October 1st to September 31st of the following year. Ecology utilizes the water year as standard protocol for assessing water quality data such as fecal coliform bacteria. The general trend since 2008 is a decrease in fecal bacteria (Figure 8). One exception is Perry Creek (SARU), which has been increasing since 2012. For the past two consecutive years, Junco Creek is the only site to meet state standards for all measures.

- At this time Snohomish County's data for North Creek Mainstem (NCLD) are unavailable. They will be included in future updates to the report.

Table 4. Annual Results for Fecal Coliform Bacteria Sampling. Reported as geometric mean (GMV) of Fecal Coliform bacteria per 100 mL for North and Swamp Creek sample locations. Red indicates exceedance of state water quality standards.

Monitoring Location	# of Samples	FC/100ml GMV	90th percentile	E.Coli/ 100ml	# of Samples	GMV	90th percentile	E. Coli 100/ml
	2006-7 Dry Season				2007 Wet Season (Spring)			
SARU	10	209	632	NSF	9	42	109	NSF
JOCO	10	55	173	NSF	10	7	35	NSF
MONT	10	187	510	NSF	10	93	207	NSF
	2008 Dry Season				2007-08 Wet Season Fall to spring			
SARU	3	115	139	82	7	192	452	NSF
JOCO	3	49	196	NSF	7	43	272	NSF
MONT	3	114	166	NSF	7	62	192	NSF
	2009 Dry Season				2008-09 Wet Season Fall to spring			
SARU	8	800	3980	703	8	184	1682	153
JOCO	8	59	1832	57	8	9	85	9
MONT	8	219	1040	205	8	132	698	108
	2010 Dry Season				2009-10 Wet Season Fall to spring			
SARU	5	104	1270	89	7	78	215	85
JOCO	5	32	190	28	7	15	38	14
MONT	5	100	740	91	7	65	230	56
LSWP	5	47	268	43	Not Applicable			
	2011 Dry Season				2010-11 Wet Season Fall to spring			
SARU	6	112	232	109	7	22	130	22
JOCO	6	20	54	20	7	11	32	11
MONT	6	181	832	148	7	20	98	20
LSWP	6	244	694	227	7	29	139	28
	2012 Dry Season				2011-12 Wet Season Fall to spring			
SARU	5	110	1136	95	7	25	58	24
JOCO	5	108	340	97	7	16	223	16
MONT	5	233	588	192	7	24	308	24
LSWP	5	185	2580	161	7	43	238	39
	2013 Dry Season				2012-13 Wet Season Fall to spring			
SARU	5	154	526	138	7	110	228	95
JOCO	5	16	46	13	7	14	23	14
MONT	5	66	873	57	7	47	130	41
LSWP	5	24	112	21	7	167	1562	148
	2014 Dry Season				2013-14 Wet Season Fall to spring			
SARU	5	341	696	NSF	7	80	314	NSF
JOCO	5	37	68	NSF	7	11	43	NSF
MONT	5	95	186	NSF	7	48	129	NSF
LSWP	5	117	3156	NSF	7	51	393	NSF

Not Sampled For (NSF)

State water quality standards: geometric mean < 50 cfu/100ml and upper tenth percentile < 100 cfu/100ml.

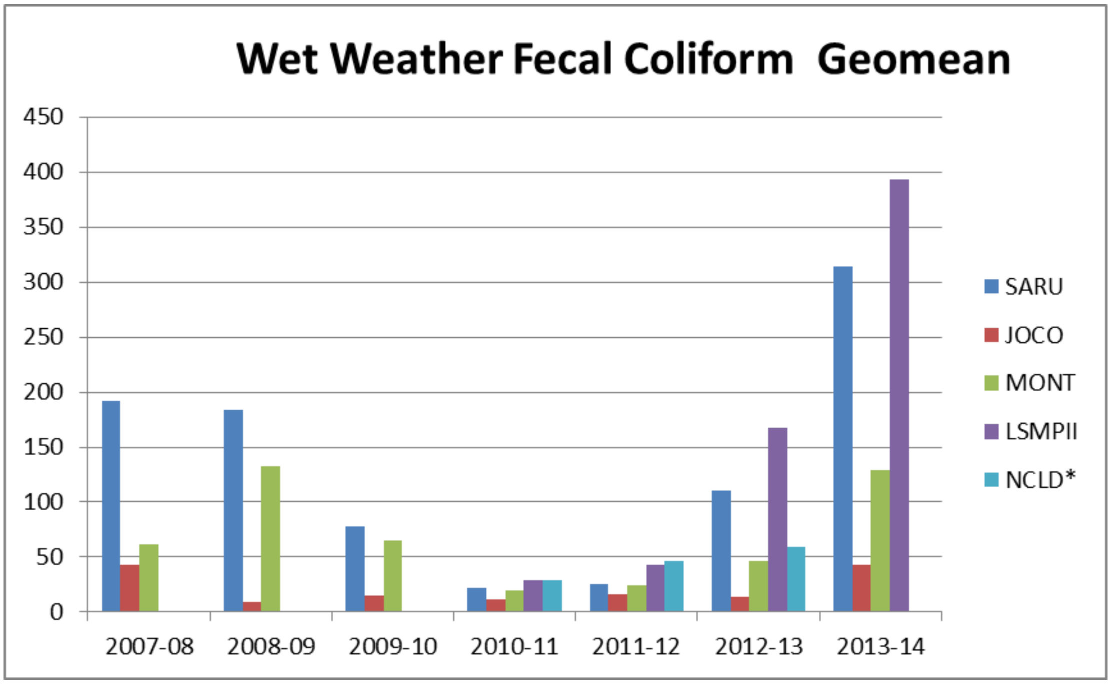

Figure 6. Wet Weather Fecal Coliform Geometric Mean from 2007-08 through 2013-14.

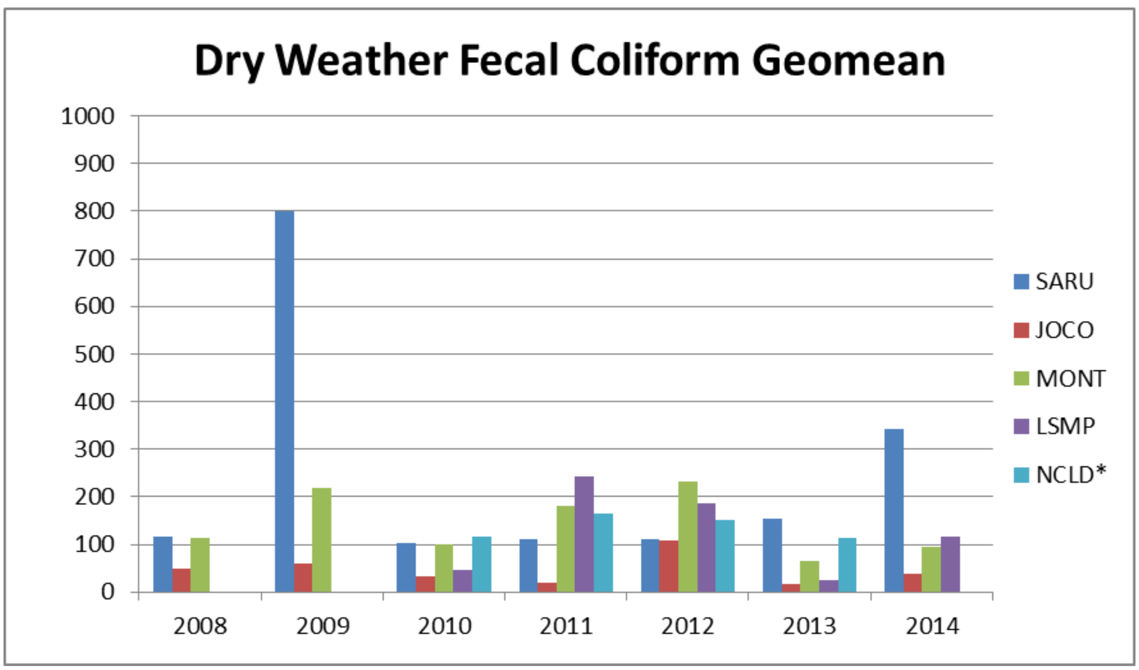

Figure 7. Dry Weather Fecal Coliform Geometric Mean from 2008 through 2014.

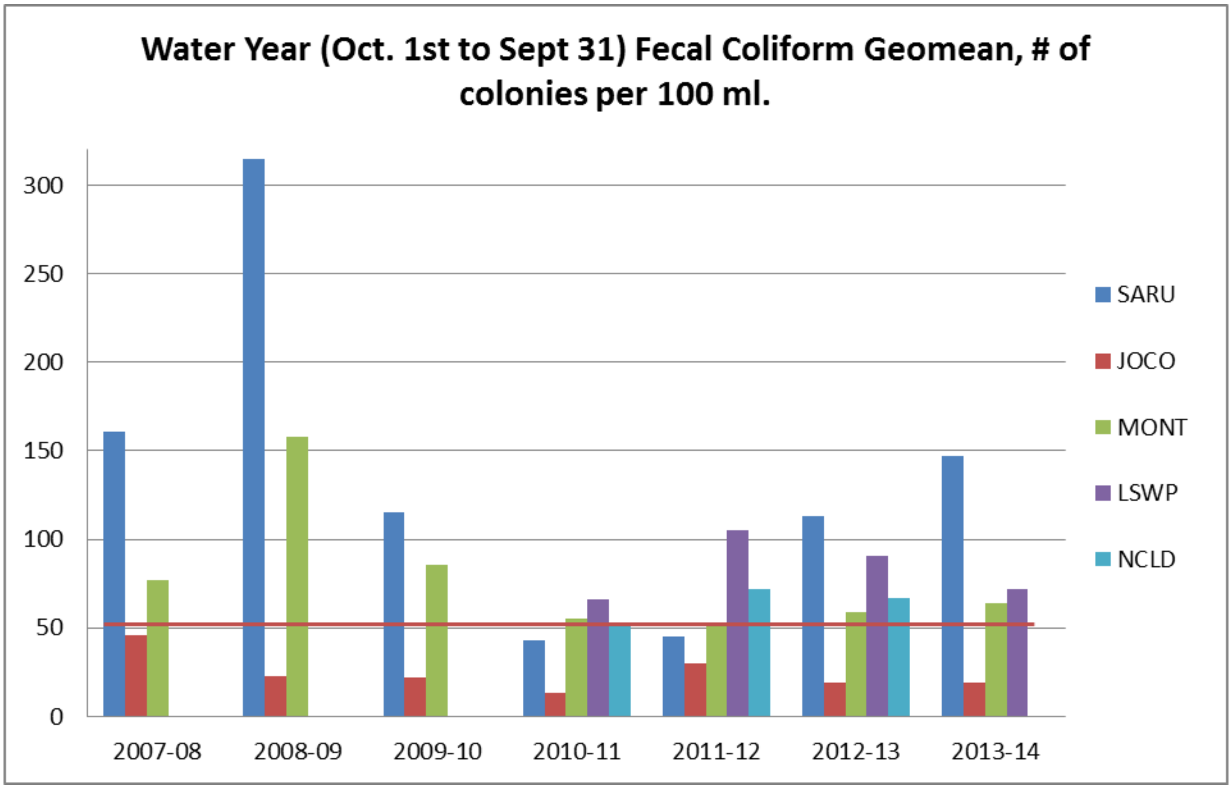

Figure 8. Water Year (October through September) Fecal Coliform Geometric Mean Bar Chart, 2008 to 2014.

Source Tracking Surveys

Two source tracking surveys were initiated in 2014 (Loch, 2014). One was in Little Swamp Creek, and the other in Queensborough Creek. Sample results are still preliminary at this time and will be addressed in a future report. Early results show that point and non-point sources are proving elusive to identify.

Summary

Results indicate improving conditions during the dry season and deterioration of conditions during the wet season since 2011. When data is viewed through the water year lens, the trend has been a general overall decrease except at Perry Creek (SURU). In all cases, except for Junco Creek (JOCO), state water qualities are exceeded for both measures of geometric mean and 90th percentile values.

What is unknown is why any of the sites have shown change. There is no systematic data collection that monitors the sources of fecal bacteria. This leads to a blindness to see the effectiveness of individual programs aimed at reducing fecal bacteria. We lack empirical data to establish cause and effect. It is prudent to begin assessing program's effectiveness to learn what works best or not at all.

The City has been actively engaged on several fronts to reduce pet and duck waste. Programs have focused on picking up dog waste and reducing the habit of feeding the ducks. It is possible that these programs directly resulted in the decline of fecal bacteria, but they may be losing their effectiveness as time progresses.

Previous source tracking surveys have had limited success (Snohomish County, 2010 and 2012). In Little Swamp Creek, source-tracking investigations found potentially contributing sources from a failed septic system and a duck feeding pond. The septic system was repaired in 2010 and efforts are ongoing to eliminate feeding the ducks at the duck pond. Recent surveys in 2014 have found no evidence of people feeding ducks, yet the ducks remain at the pond.

The two surveys conducted in North Creek tributaries provided potential improvements, and actions were taken to improve conditions. However, conditions in Perry Creek continue to worsen and there is no known cause as to why at this time.

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